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CEREAL CROPS PRODUCTION IN PAKISTAN: TRENDS INSTABILITY AND GROWTH

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ABSTRACT

Cereal grains are considered as the primary source of human diet for centuries. The present study tends to investigate trends, instability and growth in cereal crops in Pakistan. Using times series data from 1951 to 2020 (70 years). Linear, quadratic, and exponential growth models were used to forecast and find the best fitted model. Also, Coppock's Instability Index was measured for area and production of selected cereal crops in Pakistan. Results indicate that wheat, rice and maize showed a positive growth trend. While bajra (millet) and jowar (sorghum) depicted a negative decreasing trend for area and production. The Coppock Index was determined to be more in production for wheat, rice and maize (76, 74 and 85 %). Likewise, the area for the selected cereal crops did not have much variable instability in the past 70 years. In accordance to these outcomes the public line departments should intervene and promote these non-traditional cereal food crops as they are important source of nutrition. Also, it would share benefits in the country's economy.

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INTRODUCTION

Agriculture sector contributes 22.91% in total GDP of Pakistan (GoP, 2023). It plays an important role in reducing poverty, and improving the country's economy, and a provides food services (Anderson and Yao, 2003). Pakistan, being an agriculture country, has immense dependence on agriculture sector, as the country receives major food outputs i.e. wheat, rice, millet, sorghum, fruits and vegetables to accomplish basic needs of food requirements. Beyond 50% of the total daily per capita calorie and iron consumption of rural households is provided by the cereal crops (Haq *et al*., 2021).

In Pakistan, agriculture continues to be the industry that employs the vast majority of people and is crucial for social, economic, and foreign exchange reasons. The agriculture sector in Pakistan is under pressure from population growth and urbanization to not only expand production but also adapt to a shifting and diversifying food consumption pattern. Agriculture is also crucial for global economic growth and contributes 4% to the global gross domestic product (World Bank, 2022). In Asia, the agriculture productivity has been in rising state given working opportunities to poorer areas and fulfilled their food requirements. According to World Bank, 70% people of rural areas live in rural sides, their workings are closely touched with agriculture sector (Briones and Felipe, 2013). Due to insignificant policy measures, low transformational changes, shifting jobs and climatic impacts have massively lowered the sectors productivity

(Rehman *et al*., 2015).

Pakistan is a country having an agrarian-based economy, in which the agriculture sector contributes one fifth to the Gross Domestic Product (GDP). About 37.4 percent of its total labor force is linked with agriculture. About 63 percent of the country's population is the residents of rural areas and there are directly depending upon this sector for their livelihood (GoP, 2022). In addition, it is a source of foreign exchange revenue which helps to foreign reserves of the county. The existing literature obvious that the size of cereal crops in Pakistan and their foreign exchange earnings of it are lessening over time which possibly causes income insecurity among the mounting domestic population in the country. Consequently, to evaluate both the actual phenomena and the magnitude of future trends of the cereal crops in the country has been evaluated based on its result. Also, the research has suggested some comprehensive recommendations to the respective stockholders to promote an agriculturally based economic version so that the country may not face food shortages in the upcoming periods. Increasing cereal crop productivity through the adaptation of technology and the use of modern science in agriculture has been most successful in many agri-based economies, particularly in Asia. Many studies have been conducted in Asian countries to attest to the contributions made by the new science of biological innovations to rise food inputs to reduce food scarcity (Kumar *et al.,* 2021). In regions with severe land scarcities but sound market infrastructures, the returns on investments in agricultural research and irrigation infrastructure have been the highest. The fast adoption of crop intensification technologies and rising land values brought on by the increasing scarcity of arable land have been major drivers of productivity growth for rice and wheat in most of Asia. Agriculture economists have long maintained the view that current advancements in seed production, plant breeding, agricultural education, and other Agri practices can boost grain yields and offer a sustainable supply for producing bioethanol (Kumar *et al.,* 2020).

The agriculture sector in Pakistan grew by 4.4% in the current fiscal year, primarily due to stronger growth in two agricultural goods. 6.6% growth in crop production and 3.3% growth in livestock (GoP, 2022). Currently, the peasants are on stage to protest against the increasing costs of agricultural inputs, soaring prices of diesel and electricity, imposing duties on agricultural machinery, and negligence of stockholders on payment for the losses due to the spell of rains for days that caused floods. It is forecasted by agriculture researchers with the growing population of the country will face a shortage of food if urgent measures were not taken on an urgent basis by the governmental bodies. Along with other challenges confronting crop production, the natural calamity has exacerbated the issues in the country. Agriculture production is impossible without suitable rainy weather (Ahsan and Chandio, 2020). It is believed that in the past, the country had the proper weather condition, low impacts of climate change on agriculture as well as well-arranged irrigation system are the causes that the high production of cereal crops was yielding in Pakistan. Further it is suggested that the weather and temperature conditions positive influence the major crop production in Pakistan (Ali *et al.,* 2017).

In terms of providing food outputs, employment possibilities, contributing to the country's trade, promoting livestock, and other factors, the agriculture sector is a key one for the economy of the nation. In terms of providing food outputs, employment possibilities, contributing to the country's trade, promoting livestock, and other factors, the agriculture sector is a key one for the economy of the nation. A very broad range of activities that are essential to produce agricultural outputs and have their own descriptive terms, such as domestication, horticulture, arboriculture, and veg culture, as well as methods of livestock management like mixed crop-livestock farming, pastoralism, and transhumance, have come to be referred to collectively as "agriculture" (Harris and Fuller, 2014).

It is proved that Agriculture is the foundation of Pakistan’s economy. It provides various kinds of food and medicine-related resources, has a large quantity of cultivated land, and fertile soil with the best and big irrigation system are the most important qualities of our country’s wealth. Hence, the country’s agricultural land is producing all kinds of agricultural goods, particularly cereal crops. So it guarantees the base for economic growth and development such as a source of income, environmental quality and services (Kaminskyi *et al.,* 2021).

Breaking the jinx of perpetual low yield of cereal crops in Pakistan remains a challenge. The present wheat output is about 2996 kg/ha compared to India 3467 kg/ha. Likewise, the rice output is about 3953 kg/ha

compared to India 2114 kg/ha, and for maize output is higher 6436 kg/ha compared to India 3210 kg/ha. Moreover, millet output is about 999 kg/ha compared to India 1353 kg/ha, and sorghum output is about 836 kg/ha compared to India 1134 kg/ha (UNFAO, 2021).

Therefore, the present study aims to explore the growth, trend and instability in selected cereal crops in Pakistan. Major Cereal crops are wheat, rice, bajra (millet), jowar (sorghum), and Maize. These crops play a major role in food provision and nutrition security in a country. Rice, wheat, and maize play an important role in the agriculture sector as well as the country's economy (Ali *et al*., 2020).

MATERIALS AND METHODS

For this study major cereal crops were selected i.e. wheat, rice, maize, bajra, jowar. Above 50% of the total daily per capita calorie and iron consumption of households is obtained by the cereal crops (Haq *et al.,* 2021).

Data

The study is based on secondary time series data from 1951 to 2020 (70 years). The data was obtained from agriculture marketing information system (AMIS). However, the wheat crop is a major rabi season crop, while, rice is a major kharif crop which is also exported. While maize, bajra and jowar are other nutritious crops, these all are considered as cereal crops.

Analytical Techniques

Compound growth rates

Growth rate reveals the trend level of any output. It is typically described as the value contributed that causes a quantity to grow (or shrink) over time (Khan et al., 2021). Compound growth rates have been computed to see the increase and decrease in area and production of selected cereal crops. Hence for measuring the growth rates of area and production. This approach has been used by numerous researchers such as (Ali *et al.,* 2020; Hossain and Hassan, 2013). It is also applied in allied sciences, e.g. social sciences (Tunio *et al.,* 2016).

$Y_t = Y_0(1 + r)^t$ ..... (1)

Where,

Yt= area / production of selected crops

Y_0= initial (i.e. 1950-51) area / production of cereal crops

r = the compound (i.e., over time) rate of growth of Yt, where stands for the year t.

Growth models

Linear Growth Model

Linear growth model is used for forecasting trend in area and production of major cereal crops. The model can be described as follows:

$Y_t = \beta_0 + \beta_1 t + e_t$ ..... (2)

Where, Y_t represents the production predicted at time t, t represents time index, β_0 is the intercept of the model, β_1 is the annual change in area and production, and e_t is the error term of the model (Rimi *et al.,* 2011)

Quadratic Growth Model

Quadratic growth model is used to check the trend patterns. The model can be described as follows:

$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + e_t$ ..... (3)

Where, Y_t represents the area and production predicted at time t, t represents time index, β_0 is the intercept of the model, β_1 and β_2 is the annual change in area and production, and e_t is the error term of the model (Shah and Khalil, 2017).

Exponential Growth Model

Exponential growth model permits relationship in which the series increases (decreases) at increasing (decreasing) rate. The exponential trend model is defined as follows:

$Y_t = \beta_0 * \beta_1 t + e_t$ ..... (4)

Where, Y_t represents the area and production predicted at time t, t represents time index, β_0 is the intercept of the model, β_1 is the respective annual change in area and production, and e_t is the error term of the model (Shah and Khalil, 2017).

Coppock's Instability Index (CII)

The agricultural instability can be measured by different methods, such as the coefficient of variation (CV), dispersion, Coppock Instability index, etc. In this study we use the Coppock's instability index (CII) for measuring the instability.

CII =Antilog $\left(\sqrt{Vlog - 1}\right) * 100$ ..... (5)

$$V\ log = \frac{\Sigma\left(log\frac{X_{t+1}}{X_t} - m\right)^2}{n} \quad \text{.....(6)}$$

Where X_t = Area/production

t= Number of years (Time)

m = Mean of the difference between logs of X_{t+1}, X_t

Log V = Logarithmic variance of the series.

RESULTS AND DISCUSSION

Results regarding cereal crops' growth performances for the past 70 years (1950-51 to 2019-20) have been estimated, as well as the forecasted estimations of the cereal crops area and production for next 10 year have also been projected.

Growth trend for the following selected cereal crops' in Pakistan (1950 to 2020)

Table 1 reveals the 10-year growth rate trend in area and production of cereal crops. Whereas, the results show fluctuations in various periods. The area and production data of cereal crops show positive growth from 1950-60 to 2010-20 for wheat, rice, and maize. While Bajra and Jowar show declining trends in area and production. These crops have experienced various agricultural issues. Consequently, from 1950-60 to 2010-20 Bajra and Jowar's 10 yearly area and production growth rates show high fluctuations, except for one positive decade.

Table 1. Pakistan's decade-wise area and production growth coefficients from 1950-2020.

Crops	Wheat		Rice		Maize		Bajra		Jowar	
Years	Area	Prod	Area	Prod	Area	Prod	Area	Prod	Area	Prod
1950-60	-0.104	0.022	-0.196	-0.131	-0.211	-0.203	-0.172	-0.161	-0.102	-0.061
1961-70	0.343	0.912	0.374	-0.586	0.35	-0.342	-0.216	-0.083	0.031	0.286
1971-80	0.158	0.676	0.353	0.462	0.108	0.219	-0.111	-0.238	-0.241	-0.243
1981-90	0.123	0.248	0.09	0.031	0.122	0.215	-0.089	-0.264	0.118	0.141
1991-20	0.07	0.447	0.191	0.581	0.137	0.395	-0.362	0.02	-0.142	-0.077
2000-10	0.116	0.225	0.213	0.433	-0.009	0.985	0.52	0.291	-0.298	-0.293
2010-20	-0.011	0.001	0.285	0.494	0.442	1.127	-0.071	0.003	-0.109	-0.132
Pakistan	1.014	5.425	2.141	7.468	2.712	19.691	-0.545	0.128	-0.599	-0.498

Source: Author's Calculation

Table 2 depicts 10-year (2021 to 2030) future trend in area and production of cereal crops (wheat, rice, maize, bajra, and jowar). However, the area and production of wheat, rice and maize portray a significant increasing trend. Whereas, area and production of bajra and jowar portray a sluggish deteriorating trend. These findings coincide with (Abbas, 2021).

Table 3 reveals the parameter estimates for linear, quadratic and exponential models. All of the models were found to be significant ($p \leq 0.05$). The quadratic model was established to be the best suitable among the studied trend models on the basis of fitted trend curve and accuracy measures. The growth rate for wheat area increased by 100% and wheat production significantly contributed by five folds (556%) over last 70-years in Pakistan. Further the results of quadratic regression indicate that 1% change in area would change area by 321% holding other factors constant. Likewise, findings were also reported by (Ikuemonisan *et al*., 2020; Jan, 2020).

Table 2. Cereal Crops Area and Production Forecasted for 10 years.

Year	Wheat		Rice		Maize		Bajra		Jowar	
	Area	Prod	Area	Prod	Area	Prod	Area	Prod	Area	Prod
2020-21	21,989	25,929	7,647.3	6,277	3672	8,145	2403	234	443.61	57.8
2021-22	22,230	26,628	7,993.8	6,471	3738	8,506	2017	234	432.19	56.8
2022-23	22,473	27,345	9,104.6	6,672	4170	8,882	2212	234	426.59	55.7
2023-24	22,719	28,081	8,746.2	6,879	4249	9,275	2581	233	421.06	54.8
2024-25	22,968	28,837	8,999.6	7,092	4325	9,685	2191	233	415.60	53.8
2025-26	23,219	29,614	9,182.8	7,312	4423	10,113	2202	232	410.22	52.8
2026-27	23,474	30,412	10,323.4	7,538	4507	10,561	2287	232	404.90	51.9
2027-28	23,731	31,231	11,268.0	7,772	4859	11,028	1845	232	399.65	51.0
2028-29	23,991	32,072	11,992.8	8,013	5237	11,516	2003	231	394.47	50.1

2029-30	24,253	32,935	11,976.6	8,261	5305	12,025	1990	231	389.36	49.2

Variability in Cereal crops

The variability of cereal crops area and production has pivotal role for sustainable production as well as for the country's economy. Therefore, an effort has been made to estimate the relative variability in cereal crops area and production depicted in Table 4.

Table 3. Forecasting parameter estimates for selected cereal crops.

			Linear		Quadratic		Exponential	
			Coefficient	SE	Coefficient	SE	Coefficient	SE
Wheat	Area	β_0	10521.73	222.23	8957.50	230.25	11044.89	196.12
		β_1	190.80	5.44	321.15	14.97	0.12	0.001
		β_2	-	-	-1.84	0.20	-	-
	Prod	β_0	-256.13	304.94	1362.97	389.47	3076.98	117.49
		β_1	378.27	7.47	243.35	25.31	0.035	0.001
		β_2	-	-	1.90	0.35	-	-
Rice	Area	β_0	2242.00	77.69	2049.10	115.41	2544.77	57.61
		β_1	71.27	1.90	87.35	7.50	0.016	0.001
		β_2	-	-	-0.23	0.10	-	-
	Prod	β_0	85.62	116.95	609.25	158.81	869.65	38.72
		β_1	94.00	2.86	50.37	10.32	0.033	0.001
		β_2	-	-	0.61	0.14	-	-
Maize	Area	β_0	843.84	32.42	933.96	47.71	1011.89	16.60
		β_1	30.96	0.79	23.45	3.10	0.017	0.000
		β_2	-	-	0.11	0.04	-	-
	Prod	β_0	-785.70	236.46	1155.23	184.32	286.35	13.75
		β_1	71.47	5.79	-90.27	11.98	0.040	0.001
		β_2	-	-	2.28	0.16	-	-
Bajra	Area	β_0	2145.40	64.37	2539.74	75.81	2172.00	105.48
		β_1	-19.10	1.58	-51.96	4.93	-0.012	0.001
		β_2	-	-	0.46	0.07	-	-
	Prod	β_0	336.10	16.57	423.00	21.29	328.79	21.37
		β_1	-1.49	0.41	-8.73	1.38	-0.005	0.002
		β_2	-	-	0.10	0.02	-	-
Jowar	Area	β_0	1413.69	32.60	1273.53	44.76	1513.15	55.83
		β_1	-11.69	0.80	-0.01	2.91	-0.013	0.001
		β_2	-	-	-0.16	0.04	-	-
	Prod	β_0	281.72	9.70	218.09	10.82	291.69	13.19
		β_1	-1.65	0.24	3.65	0.70	-0.008	0.001
		β_2	-	-	-0.07	0.01	-	-

Source: Author's Calculation

Table 4. Coppock's Instability in percentage of major cereal crops.

	Wheat		Rice		Maize		Bajra		Jowar	
Period	Area	Prod	Area	Prod	Area	Prod	Area	Prod	Area	Prod
1951-60	40	43	41	40	40	44	41	44	39	38
1961-70	41	47	41	48	42	39	41	42	38	38
1971-80	39	43	42	43	38	40	41	41	38	39

1981-90	38	41	38	39	39	42	46	46	38	38
1991-00	38	41	40	44	39	51	46	45	38	38
2001-10	38	40	41	44	39	46	43	44	39	39
2011-20	38	38	40	42	41	85	39	39	39	39
Pakistan	47	76	52	74	52	85	51	49	42	41

Source: Author's Calculation

The Coppock Instability Index was found to be more in production than area for wheat, rice and maize (76, 74 and 85 %). Whereas, the CII indicated that bajra and jowar were less variable in production than area 49% and 41% respectively. Likewise, (Ikuemonisan *et al*., 2020; Sathiya *et al.*, 2022) also reported instability in production and area harvested.

CONCLUSION

In conclusion, the study carried out to see the growth trends in area and production of selected cereal crops in Pakistan using historical time series data of the past 70 years from 1950–1951 to 2019–20. The data was obtained from Agriculture Marketing Information Service (AMIS). Various growth models were used to estimate the performance of the major cereal crops production and growth, and to forecast the values for area and production up to 2029–2030. Findings revealed that the major cereal crop for the past 70 year (1950–1951 to 2019–20) have experienced significant variations. Results depict that major proportion of cereal crops is locally consumed and less is traded occasionally. Also, growth of cereal crops production has been consistently high between 1950- 2020 except jowar. The production of cereal crops grew at a rate as high as 19.7% for Maize. However, this growth has been largely possible primarily owing to expanded harvested. As maize production was growing, the area harvested followed a positive growth trend of 2.7%. Likewise, wheat production grew at 5.4%, rice production grew at 7.5 %, and millet production grew at 0.13% during this period. Further, the CII depicted more instability in production than area of wheat (76%), rice (74%) and maize (85%). Likewise, bajra (49%) and jowar (41%) were less variable in production than area respectively during the reference period. Thus the findings, endorses policy strategies that promote; best agronomic practices, intensive production cereal crops using improved varieties with minimal land and labour, and adequate support to fund scientific researches on how to develop improved varieties of diminishing cereal crops. In particular, appropriate reform on the existing land use policy with a view to mainstreaming land governance in investment plans and ventures of agriculture will bring boost to agricultural production among major cereal crops.

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